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Comparison of Waste Management between Indonesia and South Korea

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ABSTRACT. The waste management system in Indonesia still faces many challenges while the waste management system in South Korea is systematic and effective. This can occur because waste management in Indonesia still uses an open disposal system so that management is not optimal, the increase in population results in increased waste generated, and high adverse impacts in various sectors due to ineffective management. Meanwhile, waste management in South Korea has implemented a sanitary landfill. Another difference is that Indonesia has not implemented sustainable waste sorting, but South Korea has implemented sustainable, structural, and effective waste sorting. Therefore, further analysis of waste management in Indonesia and comparison with South Korea is necessary. This article aims to determine the differences in waste management in Indonesia and South Korea. This research was conducted using data samples such as Open Dumping Putri Cempo, Indonesia and Sudokwon Sanitary Landfill, South Korea. Primary data were obtained through study visits and secondary data were obtained through previous research. Waste management is an important thing to learn. From this study, it was found that municipal solid waste management in Indonesia proved to be less than optimal compared to municipal waste management in South Korea.

Keywords: waste management, open dumping, sanitary landfill.

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1. Introduction

The number of the population continues to increase day by day, including the number of the population in Indonesia. Based on data from Worldometer, the population growth rate in Indonesia reaches 1.07%, which is considered high. The rapid population growth resulted in increasing economic, sociocultural, and industrial growth. This can also result in a shift in the quality and function of the environment that is not in accordance with its designation (Brooks et al., 2016). For example, in rural areas where at first many trees become barren because they are used as industrial land. So that there is pollution caused by waste or industrial waste also from household waste. Actually, humans have an important role in managing the environment because humans and the environment are an inseparable unit and create a reciprocal relationship. But unfortunately, due to human attitude that tends to be consumptive and prefers practical things, the amount of waste generated increases and causes serious environmental problems. In fact, waste is very dangerous for the ecosystem because it can pollute the ecosystem. It is not only animals and plants that will be affected, but humans can also be affected. Waste is unwanted residual material after the end of a process. Waste can also be interpreted as a material that is wasted or thrown away from a result of human activity that is no longer used or is no longer desired, even waste has a negative value because of its handling, either to dispose or

clean it requires a large cost. In addition, waste that is not handled properly can disturb environmental cleanliness, cause odors, and cause various diseases (Addahlawi et al, 2019).

Types of waste are very diverse. Not all waste can decompose properly because some cannot be degraded (Wahdah et al, 2019). In general, waste is divided into three (organic, inorganic, and B3 waste). Organic waste is waste that comes from living things and can be degraded or decomposed. One example of organic waste is dry leaves (Suciati and Faruq, 2017). Dry leaves can be used in composting waste (Sulistiyorini, 2005). This type of waste can later be reused for organic fertilizer, biogas, or other products. In contrast to organic waste, inorganic waste is waste that does not come from living things and is difficult or even cannot be degraded or decomposed naturally. Although inorganic waste is difficult to decompose, inorganic waste can be recycled and used as various handicraft creations (Tamyiz et al, 2018). Used glass bottles, for example, can be reused as flower vases, decorative lamps, or other home decorations. B3 waste is waste that is dangerous and poisonous. If not treated properly, this type of waste can threaten the health and pollute the environment such as waste containing aerosols. Aerosols can cause the depletion of the stratospheric ozone layer which functions to protect living things on earth from ultraviolet radiation (Ruslinda et al, 2019).

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If not processed properly, this type of waste can threaten the health and pollute the environment, such as waste containing aerosols.

Due to the large impact of environmental problems due to waste, it is necessary to carry out proper management because waste disposal activities are endless. Therefore, proper and correct waste management is needed. Waste management in urban areas is sometimes still very poor, such as in terms of land, engineering, and others. In an urban or urban environment, several obstacles or challenges are often encountered such as relatively low public awareness, especially those selling in the market, the lack of waste collection infrastructure, and the limited number of sanitation extension workers (Nizar et al., 2017). One solution to the public awareness problem is the Ministry of Environment needs to develop a waste bank (Suryani, 2014). The role of the waste bank is an initial momentum in fostering collective awareness of the community to start sorting waste, recycling, and utilizing waste. In addition to increasing public awareness, it is also necessary to do proper waste grouping so that waste that can still be utilized and waste that is no longer valuable is not mixed. For example, in Japan, there are 3R methods or as known as reduce, recycle, and reuse (Leeabai, 2019). Because of this method, environmental problems due to waste can be reduced or even prevented.

This article was created to find out the differences in urban waste management between Indonesia and South Korea. Waste management in each area needs to be considered along with the increasing volume of waste and different characteristics of the waste according to the type of waste. Waste management in cities in Indonesia is not optimal enough which contrasts with what is applied in South Korea. In South Korea, waste management is more organized. Even though it looks complicated, the waste management applied in this country can have a positive impact on both ecological and environmental aspects. Therefore, further analysis of waste management in Indonesia and its comparison with South Korea is necessary to be researched.

2. Materials and Methods

2.1 Research Site

Research in the article analyzes the differences between waste management in Indonesia and South Korea. Putri Cempo Open Dumping and Sudokwon Sanitary Landfill were the samples on this research. Data and information about Putri Cempo Open Dumping were obtained at Putri Cempo Open Dumping, Surakarta, Indonesia in 2019. While data and information about Sudokwon Sanitary Landfill were obtained at Sudokwon Sanitary Landfill, Incheon, South Korea in 2015.

2.2 Sample Collection and Research Methods

Primary data and secondary data in this study were obtained by taking and collecting data from various sources. The two main data were collected with information on visits to Putri Cempo Open Dumping and with a case study on other articles in the form of data on Sudokwon Sanitary Landfill. Both of these data are qualitative data. Putri Cempo Open Dumping was taken as one of the open dumping samples in Indonesia, while Sudokwon Sanitary Landfill was taken as one of the samples of a sanitary landfill in South Korea. Data and information about Putri Cempo Open Dumping were obtained through study visits and interviews by students of the Environmental Science Department from the University of

Sebelas Maret in 2019. While data and information about Sudokwon Sanitary Landfill were obtained through study visits on Landfill Operation and Resource Training Program through the Korean International Cooperation Agency (KOCA) in 2015. Although the data about Sudokwon Sanitary Landfill was carried out in 2015, the condition in the Sudokwon Sanitary Landfill is not much different, so it can be used as a case study in this article. This condition caused by the standards and procedures used at Sudokwon Sanitary Landfill is still the same. These two samples serve as comparison data for final waste management in Indonesia and South Korea.

3. Result and Discussion

3.1 Waste management

Waste management is a systematic, comprehensive, and sustainable activity that includes waste reduction and handling. Municipal waste management in Indonesia is an actual problem in line with the increasing rate of population growth, which results in an increasing amount of waste generated (Mahyudin, 2017). Analysis of the problems faced in waste management in Indonesia, including the lack of a firm legal basis, inadequate landfills, a lack of composting efforts, and a lack of proper landfill management (Chaerul et al., 2007). Whether or not waste management is good, it is not only based on the technical aspect but also includes non-technical aspects. A good management system requires a variety of disciplines, such as civil engineering.

Behind the success of waste management in South Korea as it is today, especially the Sudokwon landfill, which is the largest sanitary landfill in the world and is already classified as a world-class sanitary landfill. Around 1977, waste management in South Korea was still not well managed. Garbage and waste pollution, both domestic and industrial waste, pollute groundwater, and the Han River, which is the river that divides Seoul City. At that time, waste processing in South Korea was centered at the Nanji Landfill. Nanji Landfill still operated with an open dumping system, which is open dumping without any processing. The Nanji Landfill was finally closed in 1993 and converted into an institution-based TPST. The former landfill land is used as a park. Then the waste goes to Mapo Resources Recycle. TPST Mapo Resources Recycle is equipped with an incinerator with a capacity of 750 tonnes/day, which can generate electricity of 5MW. This system is used by residents around Mapo Resources Recycle as a source of electrical energy.

3.2 Waste Management in Indonesia

Waste generation in Indonesia continues to increase from year to year. In metro cities and big cities, waste generation is estimated to reach an average of > 500 tons/day, while in medium cities with a population of <500 people/ha, the average waste generated is 100-300 tons/day (Directorate of PLP Development, 2016).

The landfill is still the main choice in waste management in Indonesia. Only about 10% of waste is used (Ministry of Public Works and Public Housing, 2016). Most of the landfill operations in Indonesia are still in the form of an open dumping system. Whereas Article 44 of Law Number 18 the year 2008 concerning Waste Management mandates that by 2013 every regional / city government already has a landfill that is representative and meets technical and environmental principles (sanitary landfill).

One of the problems caused by garbage is the decline in aesthetics around the landfill, which has the potential to cause social conflict with the surrounding community. The opposition made by the surrounding community is generally related to causes that endanger health, safety, reduced, comfort, and limited land, especially for the placement of landfills. Some examples of social conflicts that occur in the community regarding the location and improper management of landfills are presented in Table 1.

Table 1. Examples of social conflicts and environmental problems related to landfill

No.	Example Case	Location
1	Environmental pollution and community rejection of the Galuga Landfill in 2009	Bogor
2	Community rejection of the operation of the Bantar Gebang Landfill	Bekasi
3	Community rejection of the operation of TPST Bojong	Bojong, West Java
4	Community rejection of the operation of Landfill Jangkurang	Garut Mojokerto, East Java
5	Rejection of the Sumompo Landfill as a regional landfill	North

The presence of a landfill can also certainly create a conflict between the functionality and aesthetics of a landfill. Inappropriate selection of landfill sites and open dumping systems results in a wide range of negative impacts, such as impacts on health, pollution, aesthetics, and social problems. The landfill, which operates on an open dumping basis will produce by-products in the form of methane gas and leachate. Leachate influences the properties of groundwater such as high concentrations of total dissolved solids, electrical conductivity, hardness levels, chloride, COD, nitrates, and sulfates, and contains heavy metals, where the content tends to decrease after the rainy season and increases before the rainy season (Vasanthi et al., 2008). Leachate produced by landfills is difficult to control even with strong protection at the landfill. Moreover, unmanaged landfills greatly affect the movement of leachate into the surrounding area (Pujari et al., 2007). Wangyao et al. (2010) examined methane gas produced in landfills and found that methane gas emissions in the rainy season are six times higher than during the dry season.

Based on SNI 19-2454-2002, the operational technical procedures for urban waste management include the basics of planning for:

1. Service area
2. Service level
3. Operational techniques, starting from waste handling; Garbage collection; Waste removal; Garbage transport; Waste processing and sorting; then final waste disposal.

Sorting and recycling activities are carried out as much as possible, starting from container to final waste disposal. According to Mahyudin (2017), the final processing of waste, in general, is using a land disposal system (removing waste into the ground).

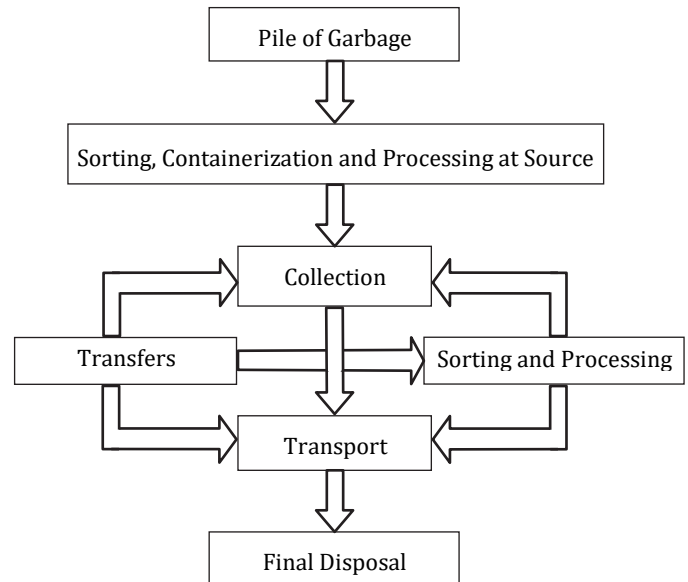


Fig 1. Technical Diagram of Waste Processing Operations
Source: SNI 19-2454-2002

Community participation is at the core of all planned waste management programs (Hendra, 2016). So that the community can participate in helping government programs in waste management is how to familiarize people with behavior that is by the objectives of the program. These include the approach on How to change people's perceptions of orderly and orderly waste management; Local social, structural, and cultural factors; and Habits in waste management so far.

Problems that occur are related to community participation in solid waste management, namely the uneven distribution of the population; The desire to protect the environment has not been institutionalized; There is no standard pattern for community development that can be used as a guideline for implementation; There are still many sanitation managers who have not included counseling in their programs; and Management concerns that community initiatives will not fit the existing management concept (Damanhuri, 2010).

Besides, the achievement of access to waste services in Indonesia is still low. According to the 2015 Basic Health Research (Riskesmas) data, access to solid waste services in Indonesia at the national level reached 86.73% (this value includes total waste management: meeting and not meeting NSPK). Table 2 below will show the achievement of access to waste management in Indonesia, which consists of the achievements of rural, urban, and national levels.

Table 2. Achievements of Access to Waste Management in Indonesia

Access achievements Waste Handling	Year 2010	Year 2013	Year 2015
Rural	73.70%	72.60%	82.00%
Urban	87.40%	87.00%	91.43%
National	80.50%	79.80%	86.73%

Source: Riskesdas. 2015

Law Number 18 of 2008 concerning Solid Waste Management mandates waste reduction and handling. This is reinforced by the Regulation of the Minister of Public Works Number 3 of 2013 concerning the Implementation of Facilities and Infrastructure for Handling Household Waste and Waste Similar to Household Waste, which mandates the sorting and sorting from the source of the waste.

One of the causes of waste management problems is the inadequacy of legal regulations governing community participation in waste management, which results in inefficient waste management in Indonesia. For example, according to Ernawati et al. (2012), one of the waste management problems that occur in the city of Semarang is the weak law enforcement against the implementation of the Sanitary Regulation and the provision of sanctions for violators of the regulations. The existing legal regulations do not specifically regulate the waste management system. The most recent regulation, which is Law No. 18 of 2008 concerning Waste Management, is not implemented properly due to the low level of waste management services.

In addition, the municipal solid waste management model adopted by Indonesia still refers to types of land-clearing technologies and is more suitable to be applied in developed countries. This is because the urban waste management model in developing countries does not consider simple waste processing, scavenger activity, low levels of waste management services, and a lack of accurate data on waste (Mahyudin, 2017). The involvement of the local government as the party most responsible for managing the waste of a city makes the recycling rate of municipal solid waste not optimal. It can be concluded that the resolution of the waste problem that is not comprehensive from upstream to downstream and involves all parties is the main obstacle to the implementation of unsustainable waste management.

The pattern of waste management in Indonesia should be carried out by establishing a Waste Bank, increasing recycling, making compost from organic waste, which is a form of ecocentric management, where this form focuses not only on the impact of pollution on humans but also on life as a whole (Keraf, 2010). If Indonesia can do it well, there will be many positive impacts. The better if it is supported by waste management that focuses on processing and reducing pollution and involves the community or community-based. TPS Tlogomas Malang has increased the role of community participation in the landfill, then it can reduce the amount of waste by recycling 1,865 tons of waste/year and at the same time reduce the carbon footprint by 72%.



Fig 2. Location of Putri Cempo Landfill

Source: Alicia, F., College Student of Environmental Science Department, University of Sebelas Maret, 2019

Putri Cempo Landfill is the final disposal site for all waste disposal processes throughout Solo Raya. Putri Cempo Landfill is located in the Kampung Jatirejo area, Mojosongo Village, Surakarta. Garbage in the city of Surakarta is collected and transported to Putri Cempo Landfill except for B3 (Hazardous and Toxic Materials). Putri Cempo Landfill every day produces about 300 tons of garbage. At Putri Cempo Landfill, there is no waste sorting process for the landfill management, the sorting around the landfill is only done by scavengers. There are several problems found in Putri Cempo Landfill which differ depending on the season, during the dry season the problems that occur are frequent burning of garbage, mostly caused by methane gas under the pile of garbage. Meanwhile, during the rainy season, the problem that occurs is the appearance of an unpleasant odor in the vicinity of the landfill due to the dampness of the garbage, besides this, it also has an effect on the roads that become slippery and makes the process of disposing of garbage to the landfill more difficult. To solve the problem, the manager of Putri Cempo Landfill has implemented the Open Dumping program.

There are three people who are responsible for managing waste, namely:

1. Sub-district: Responsible for managing urban village waste with TPS Mobile, TPS Mobile is a garbage collection service with an L300 car and a fleet that includes drivers and assistant drivers with the number of pickups and drivers depending on the respective sub-district.
2. Trade Office: Responsible for overseeing the waste management of markets in Solo.
3. Department of Environment: Responsible for managing waste in parks and main lanes in big cities.

In the waste service retribution, one household sector or one business sector is asked to pay Rp.3,000-5,000 per month. In addition to the landfill, there is another management agency in the form of a Waste Bank. However, public awareness of the role of the Waste Bank itself is still lacking.

Sukrorini et al. (2014) revealed that, waste management at Putri Cempo Landfill can be called waste management which is carried out by integrated open dumping. With the collaboration between Department of Sanitation and Gardening, scavengers, and cattle breeders who apply the 4R system (Reduce, Reuse, Recycle, and Recovery). Example of reduce from cattle that eat organic waste; used plastic packaging is made into tissue holders, pencil cases, letter holders, and other crafts; used paper is made into bags, tissue holders, letter holders, wallets, and other crafts; used plastic bags are made decorations to resemble bonsai plants. Examples of reuse from scavengers who reuse used mineral water bottles into liquid fertilizer and used cans that are reused as plant pots. Examples of recycled plastic bags and other used plastics are recycled back into household utensils, such as buckets, scoops, plastic bags, etc. and used paper that is recycled into new paper again. Examples of recovery from organic waste in Putri Cempo Landfill can change previously barren land to fertile and leachate which can be used as a liquid fertilizer to help plant growth, stimulate flowering and fertilization, polish leaves, and grow roots.

So, waste management at Putri Cempo Landfill does not only have a negative impact, but there is also a positive side to the environment around Putri Cempo Landfill. The volume of waste can be reduced by the activity of scavengers, amounting to 200 people who can reduce it by approximately 20 tons/day. Meanwhile, as many as 900 cows in Putri Cempo Landfill can reduce the volume of organic waste by approximately 11 tons/day. This means that in the rainy

season the volume of waste piles decreases from 250 tons/day to 219 tons/day. And in the dry season, the volume of landfills decreases from 220 tons/day to 189 tons/day.

Waste management at Putri Cempo Landfill apart from implementing an open dumping system, Putri Cempo Landfill also implements the garbage power plant program. The garbage power plant program was established in 2016 and will officially start construction in 2020 and the distribution of electricity production will begin in 2021. The technology used in processing this waste is known as "gasification". The volume of waste that enters the Putri Cempo Landfill every day is influenced by the season. In the dry season, the average volume of waste entering Putri Cempo Landfill is 220 tons / day, while the average volume of waste in the rainy season is 250 tons / day. In its management, waste must go through a selection, because metal, wood, iron, and glass cannot be processed by machines and must go through a filter to remove stones, soil and debris or fragments from several types of waste that cannot be processed. This processing machine does not remove any residue. The end of this process is the production of briquettes, these briquettes are used to drive turbines and generate electricity. Then, the electricity produced will be purchased by the PLN (producer).

3.3 Waste Management in South Korea

In 2000, the South Korean Ministry of Environment established the Sudokwon landfill Site Management Corporation, a state-owned company that collaborates with the Seoul Metropolitan City Government in planning and building, operating, maintaining, and maintaining waste processing infrastructure, particularly in landfills and their supporters. Sudokwon landfill is the largest sanitary landfill in the world and is classified as a world-class sanitary landfill. The gas and leachate produced are stored and processed to become valuable resources. The largest landfill site in the world has developed into the best natural attractions. Waste turns into resources, the former landfill is reborn into a dream park known as a dream park.



Fig 3. Location of Sudokwon Landfill

Source: Sudokwon Landfill Site Management Corporation, 2015

With an adequate land area, the landfill is divided into 4 waste processing units. The maximum pile height is planned for 40 meters. Currently, SLC is preparing to build a third waste processing unit covering an area of 307 hectares, which will be built in 2016. This is to anticipate that the second waste processing unit will be full in 2017 or 2018. The volume of waste that enters the Sudokwon Landfill is around 14 tons/day consisting of household waste, construction waste, and office activity waste. The incoming waste management

system facility is very sophisticated because it is equipped with an automatic sampling system, a control system integrated with a wireless network and CCTV spread over 110 locations around the landfill.

The South Korean government has implemented a policy for sorting waste at source classified as organic waste; Inorganic waste; and Other waste that does not fall into that category, for example, eggshells, disposable diapers, and others. The community is required to sort their waste first before putting it into plastic bags according to the type of waste, especially waste that can still be recycled. The community is also encouraged to carry out a waste recycling process, for example by returning a used drink bottle that was purchased, the community will get a deposit for the purchase price of the drink. Waste recycling activities carried out by the community are quite successful. They create communities that help oversee waste handling in their respective environments.

In the field of waste management, the Government of South Korea provides support in the form of preparation of laws, regulations, and their implementation. Since 1986, a Waste Management Law has been drafted which includes waste classification, division of responsibilities of each stakeholder, and waste processing techniques, including recycling techniques. In 1990, the South Korean Government implemented the concept of a volume-based waste fee system and collecting the recyclable waste, namely a volume-based waste disposal system, where each citizen has to pay for every plastic waste to be used. In 1998, the South Korean Government also implemented an Extended Producer Responsibility (EPR) policy, which obliges companies and industries to recycle part of their product. In 2008, 69,213 tonnes of plastic products were successfully recycled, with an economic benefit of US \$ 69 million. By recycling products specified by the EPR, South Korea has reduced carbon dioxide emissions by an average of 412,000 tonnes per year. In 2007, 57.8% of solid waste was successfully recycled and only 23.6% was disposed of. In the same year, as much as 81.1% of the total waste was successfully recycled.

3.4 Comparison of Waste Management Systems in Indonesia and South Korea

The waste management system in Indonesia is compared to the waste management system in South Korea in terms of 5 aspects of waste management, as follows:

1. Institutional Aspects
The waste management institution at the Putri Cempo landfill, Indonesia is unclear between the regulator and the operator, while at the Sudokwon landfill, South Korea it has been separated between the regulator by the Ministry of Environment and the operator managed by the Sudokwon Landfill Site Management Corporation (SLC).
2. Fund Aspects
Indonesia is still facing the constraints of limited funding sources for investment, operation, and maintenance, which results in less than optimal waste management. Meanwhile, in South Korea, sufficient funding sources come from the government budget, tipping fees from the local government, business profits from the sale of gas, landfills, CDM projects, research activities, and sales of plastic bags to the public (Hendra, 2016).
3. Policy Aspects
Regulations related to solid waste in Indonesia are still limited, both nationally and locally, law enforcement is still weak. Meanwhile, in South Korea, there have been

many regulations related to solid waste, both technically, in management, and in the financing, along with clear law enforcement.

4. Social Aspect

The main stakeholder in waste management besides the government is the community. Without community participation, all programs that have been made by the government will be in vain. Because the community is the first-hand producer of waste. In Indonesia, public awareness to participate in managing waste is still low. The community is still not involved in waste management. Meanwhile, in South Korea, people have a high awareness of managing waste, for example by sorting waste at the source and carrying out the recycling process. There are communities that assist in supervising the handling of waste in their respective environments. In waste management in South Korea, before waste enters the landfill, waste is usually managed in a structured manner. Waste is separated based on its type, not just organic and inorganic like in Indonesia. The disposal of waste from each house is carried out in a sustainable manner and uses plastic bags by region. Ordinary waste is sorted by type (glass, rigid plastic, soft plastic, paper, cardboard, used lamps, used battery stones, etc.) which has even begun to be differentiated by color and disposed of in the waste sorting box directly. Meanwhile, food waste is disposed of using regional plastic bags that can be purchased at the nearest supermarket. For use, clothing waste is disposed of in a special place and the machine that is usually free for collection and for donations. For household furniture waste, the disposal is done through registration at the nearest regional office and will then be collected by the officer. Then make a payment. The furniture waste has a sticker attached and will be picked up by the officer.

5. Operational Technical Aspects

In principle, the operational techniques for waste management in Indonesia and South Korea are almost the same, namely: storage/container, collection, transfer, transportation, and disposal/processing. Most of the landfill in Indonesia still operates on an open dumping basis, while in South Korea the operation of the landfill is carried out by means of a sanitary landfill, which is equipped with supporting facilities and infrastructure.

6. Conclusion

From this study, we can conclude that municipal waste management in Indonesia has proven to be less than optimal compared to municipal waste management in South Korea. It can be seen from the differences in waste management systems and recycling rates at the Putri Cempo landfill and Sudokwon landfill, which are used as samples of landfills in Indonesia and in South Korea. Putri Cempo's landfill uses an open dumping system which results in negative health, social, and environmental impacts because it does not go through a sustainable sorting process. In addition, community participation and government policies in Indonesia itself regarding waste management are still low. Meanwhile, at the Sudokwon landfill, a policy has been implemented in sorting waste by type so that the recycling rate of waste is high. This is because government policies and public awareness in South Korea are classified as high and sufficiently detailed. This is supported by the fact that Sudokwon's landfill is managed with a sanitary landfill system (integrated management), the

application of the concept of a volume-based waste fee system, and collecting the recyclable waste. Another policy is extended producer responsibility, which requires producers or companies to recycle the generated waste.

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